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AN ANALYSIS OF ELECTROMAGNETIC POLLUTION

BY

Henry K. Kellner, Major, USAF

A RESEARCH STUDY SUBMITTED TO THE AIR FORCE FACULTY

May 1979

FORT LEAVENWORTH, KANSAS

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) An Analysis of Electromagnetic Pollution		5. TYPE OF REPORT & PERIOD COVERED
7. AUTHOR(s) Major Henry K. Kellner, USAF		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army CGSC, Fort Leavenworth, KS 66027 ATTN: ATZLSW-AF		8. CONTRACT OR GRANT NUMBER(s)
11. CONTROLLING OFFICE NAME AND ADDRESS Same as # 9		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Master's thesis		12. REPORT DATE May 1979
		13. NUMBER OF PAGES 27
		15. SECURITY CLASS. (of this Report) UNCLASSIFIED
16. DISTRIBUTION STATEMENT (of this Report) Distribution Unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Approved for Public Release, Distribution Unlimited.		
18. SUPPLEMENTARY NOTES MMAS Thesis prepared at CGSC, Fort Leavenworth, KS 66027		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Microwave leaks, Electromagnetic pollution, pacemaker hazards		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This document covers the effects of microwave and electromagnetic energy on everyday devices in use world wide.		

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CHAPTER I

INTRODUCTION

Over the last several years, there have been many articles in newspapers and magazines concerning the effects of microwave ovens, the mysterious openings and closing of electrically operated garage doors, the hazards of electronic radiation to people wearing pacemakers, and the hazards to aircraft from the walkie-talkies operated as toys by children. One magazine article noted the following diverse forms of electromagnetic pollution.

1. En route from Miami to San Francisco, a jetliner's navigational system suddenly indicated that the plane was headed for Mexico City.
2. A banker wearing an implanted cardiac pacemaker nearly died when he stood close to a commercial microwave oven, and a woman using a similar device was thrown into cardiac crisis by diathermy equipment near her hospital room.
3. A Colorado businessman (who should have known better) used properly functioning equipment operated on a licensed frequency to call his office by radio from a construction zone; three members of a work crew narrowly escaped death in the blast and rock slide he triggered.
4. Radar systems of a major airport went haywire due to uncontrollable disturbances. The trouble began on Christmas Day. "Now we've learned to expect an annual battle with interference from toy walkie-talkies. Thank God those things break after a few weeks," said a FCC engineer.
5. Memory banks of a big Louisiana computer system were crippled when stored information was suddenly erased by radar from a nearby airport. (3:42)

The environmental effects of pollution has been discussed more frequently by many people over the past few years and the technological achievements of man have had an increasingly significant impact upon the environment. Of all the discussions conducted on pollution, chemical pollution seems to be the greatest concern. Much effort is being expended to clean up the environment from its effects; billions are being spent by governments and industries to purify our air and water supplies. However, one form of pollution that hasn't received the attention of people and especially the media, to the extent that chemical pollution has, is energy pollution. "Man may soon enter an era of energy pollution of the environment comparable, in public health and ecological implications, to the chemical pollution of today." (9:1)

Energy pollution comes in many forms, some of which are as follows: waste heat from nuclear power plants, noise, vibration, light, and electromagnetic energy. In this paper I will be concerned with pollution in the form of electromagnetic energy and its effect on man and the environment.

Purpose of the Paper

The purpose of this study is to report some of the findings concerning electromagnetic pollution. These findings have been gathered through a search of articles available in the press and in learned journals. Compared to other forms of pollution, little research is being reported on electromagnetic pollution. This study represents a non-technical study of research.

This study will present a detailed background to the subject followed by the sources and causes of electromagnetic pollution (microwave ovens and power line leakage), Project Sanguine, therapeutic uses of electromagnetic energy, and occurrences of known electromagnetic pollution. The final chapter will present conclusions drawn from readings for this paper.

CHAPTER II

BACKGROUND

What is Electromagnetic Pollution?

Electromagnetic pollution is nothing more than the permeation of the environment (air, land, water) with undesirable static and alternating electric and magnetic fields. (2:1) While many fields may be natural, they are more than likely man made. We have always been surrounded by those fields created by lightening, wind and the radiation generated by the sun. These natural fields have had some influence on man, but it is the man made electromagnetic fields from power generation, communication, ranging and electrical processing systems which will be addressed.

The pollution from static and alternating electromagnetic fields is different from the other types of pollution (air, water and noise) in two ways. First, it is almost always invisible and, secondly, there may be therapeutic effects. We are all familiar with seeing, smelling, feeling and tasting air and water pollution as well as hearing and feeling noise pollution; but, one seldom senses electrical pollution and therefore most people are not aware of the presence of this type of pollution.

History

More than 3,000 years ago in Egypt and India electromagnetic radiation, in the form of sunlight, was being used to treat a skin condition (vitiligo), manifested by smooth milk-white spots on various parts of the body. The spotted areas were painted with a mixture containing furocoumarins, which conveys the photodynamic action in bacteria, and then exposed to sunlight. Neither light nor the coumarins had any effect on killing bacteria by itself, but the combination of the two ingredients was most effective. The energy absorbed by one molecule is conveyed to a biologically important molecule, which is changed and thus lethal damage is inflicted on the diseased cell. (7:1)

Man's contribution to electromagnetic pollution probably began with Pieter van Musschenbroek, when he invented the high voltage, low current electrostatic generator in 1746. This was followed by Alessandro Volta when he invented the low voltage, high current primary battery in 1800. Fortunately, the primary use of these inventions was originally localised to research laboratories. It was at the turn of this century that electric power became available to the general public for lighting, transportation and motors. It was then that the electric and magnetic fields, from the power generating and transmission systems, found their way into homes, factories, schools, offices and streets.

Perhaps the single most significant phenomena in the electromagnetic arena was the development of the military radar which operates in the microwave region of the radio-frequency spectrum. Microwave energy is generally produced by means of a specially constructed electronic tube such as the magnetron or the klystron. The former was invented by Albert W. Hull of the General Electric Research Laboratories in 1920, the latter was developed by the Varian brothers and W.W. Hausen in 1938. (7:4)

In the late 1930's, after further development, these electronic tubes were capable of producing several hundred watts of power at varying wavelengths. At the same time physicians at the Mayo Clinic had become interested in microwaves for such radiation could be valuable in medicine. However, just when tubes of sufficient power had been developed, they became mysteriously "unavailable". It was not until the secret of radar was finally revealed that it became evident such tubes had been designated for military use only and would not be in the civilian sector for many years. (7:4)

The study of the biological effects of microwave radiation became more widely known in May 1957 when Dr. J.T. McLaughlin published an article about their injurious effects to the human body. The article was entitled "Tissue Destruction and Death from Microwave Radiation (Radar)" and appeared in the California Medicine. It reported the death of a man who stood in the direct beam of a radar transmitter. In a few seconds the man had a sensation of heat; the heat became intolerable in less than a minute and he moved away

from the antenna. Within 30 minutes he had acute abdominal pain and vomiting. Several operations were performed but he died within ten days from inflammation of the intestines attributed to destructive heat generated by the radar beam. It was not possible to determine exactly what power was involved in this particular case, but the equipment was capable of delivering 300 watts average power. (7:5)

The real dawning of an awareness of just how potentially dangerous invisible electromagnetic radiation is came in 1957. Despite an increased interest and detailed research all dangers are not yet readily known.

The following chapter will take a closer look at microwave ovens, power line leakage, Project Sanguine and therapeutic uses of electromagnetic energy.

CHAPTER III

APPLICATION OF ELECTROMAGNETIC POLLUTION

The Microwave Oven

The small-size microwave oven is probably the most notorious potential source of harmful microwave radiation. As a result, the microwave oven has probably elicited the greatest concern of any electronic device with respect to radiation and the deleterious effect of radiation from microwave ovens has been discussed in consumer group publications. (2:28)

The major potential problem with microwave ovens is that they may leak microwave radiation when in operation. The safety of microwave ovens involves their design and operation. It is difficult to build a microwave oven that is completely emission-free; further, owners do not follow the instructions for operating the ovens and fail to comply with safety procedures recommended by the manufacturers.

The microwave agitates the food molecules which produce heat and the heat in turn cooks the food. These same microwaves, when allowed to leak from the oven, can cause the same thing to happen to human and animal tissues, which can be as dangerous as any chemical pollutant. It may even be worse since people normally have no sensory organs to detect dangerous levels of microwave radiation.

The threat of electromagnetic pollution from microwave ovens may grow rapidly as more people buy this latest gadget for the home.

Microwave oven manufacturers have been continuing to search for ways to make their product safer. It can probably now be stated with accuracy that the electric and magnetic fields radiated by microwave ovens, if they meet and are operated to the required standards, are less than the fields existing around standard electric ranges. (2:32) Problems arise when units are poorly manufactured and not operated correctly.

Power Line Pollution

Recently, headlines have been appearing in national newspaper cautioning the public about the environmental impact of high voltage lines. Today thousands of miles of high voltage power lines criss-cross our landscape. Some of the larger power lines operate under the power of 2,000,000 volts. The two important pollution hazards from these types of power lines are, the air pollution resulting from chemical reactions that take place in the corona discharge, and electromagnetic pollution in the form of strong electric fields that exist in the vicinity of these lines. (10:34)

Extremely high voltages carried on bare, unshielded conductors often pass overhead in many places as low as 40 feet above roads and farms, causing strong electrostatic fields in the vicinity.

These electric fields can produce dramatic effects. A person can walk within the vicinity of a transmission line holding an ordinary fluorescent light bulb and it will illuminate without cords, batteries, or electrical connections to the ground. This phenomena occurs at a considerable distance from the utility's right-of-way. Many people live and work in these regions. (10:34)

In 1962 the Soviet Union conducted some extensive studies of 250 men working at 500,000 and 750,000 volt substations. The result of these studies was the establishment of time/exposure standards for working in these electric fields. According to these regulations, no one should be exposed for any time to fields over 25,000 volts per meter without special protective screens. In a field of 25,000 volts per meter the maximum exposure should be 5 minutes in a 24-hour period. At 10,000 volts per meter, 180 minutes are allowed; 5,000 volts per meter is considered as the level where any length of exposure is considered safe. A farmer riding on a tractor under a 765,000 volt line would be exposed to an electric field so intense that the Soviets would not allow their personnel to be exposed to it for even one minute. (10:35)

It is also interesting to note that the electrostatic fields, as measured by the Soviets, are the fields at the working position or the average height of a man standing on the ground. On the other hand, our power companies report only average ground level field strengths and these levels are much less than the fields to which

people are exposed when standing or riding horses or tractors under 765,000 volt lines. (10:35)

Even with this dramatic evidence, little research has been done by power companies to determine the short and long range effects of strong electric fields. Electric companies in the United States have known of the Soviet research since 1972; however, the results were brushed off with a comment that a: "Comparison of two diverse populations with entirely different cultures, working conditions, and environment, should be viewed with great caution." (6:1308) In the meantime, in answer to questions from concerned citizens about the safety of the new extra-high voltage lines, electric companies state that there is no evidence of ill effects caused by these lines. (10:35)

Project Sanguine

Sanguine, was the name given to a proposed long-range project by the United States Navy Department to develop a reliable and survivable communication system for the transmission of high priority command and control messages, worldwide, to submerged submarines and other United States forces, from a single underground transmitting location in the United States. (2:21)

As originally proposed the Sanguine antenna was to occupy about 21,000 square miles and was to be located in Northern Wisconsin. The lines were designed to radiate as elements of an

antenna and were to carry 14,000 volts; they were to be buried six feet underground in a large grid pattern. As a result of the public concern about the possibility of biological damage from the electromagnetic fields, the Navy commissioned some studies. The first of these were completed in 1970 and showed a number of effects ranging from increased mutation rate in fruit flies to high blood pressure in dogs. These early studies were considered to be inconclusive and follow-up experiments were ordered. (9:36)

It is interesting to note that, as originally proposed in the Sanguine case, the voltage gradients in the air would have been several orders of magnitude less than those caused by typical overhead power lines of 765,000 volts. The Navy had decided to reduce the voltage they would use so that the electromagnetic fields would be less powerful than originally planned and in fact only about one-thousandth as strong as the ones at ground level under a 765,000 volt power line. So far, only a few of the new follow-up studies have been completed and they are also considered to be inconclusive. (9:36)

The message here is quite clear, the electric fields in air under extremely high voltage lines (765,000) are thousands of times greater than the Sanguine fields, but the general public has not objected to the power lines. The Sanguine Project appears to be the first technological development to be attacked by the general public solely because of the possible effects of electromagnetic

fields on the environment. The big investor-owned power companies do not use federal funds and are not required to issue environmental impact statements, constraints with which the Navy must comply. The net result is that we have effectively halted Sanguine and looked the other way to high voltage lines with electric fields which are thousands of times more powerful.

Therapeutic Uses of Electromagnetic Energy

You will recall that electromagnetic pollution is different from other types of pollution in that it is invisible and that there may be therapeutic effects. Dr. Robert O. Becker of the Veterans Administration reinforces this concept when he states that "...these effects can be good or bad.." In this section we will explore some of these "good" effects followed by some of the "bad" effects.

Speaking before a 1974 New York Academy of Sciences Conference, Dr. Becker had this to say about electrically mediated growth mechanisms in living systems.

The true depth of knowledge in this area (electrically mediated growth mechanisms in living systems) is extremely shallow. The significance of all this is that electromagnetic phenomena do have biological effects. We know that. We also know that these effects can be good or bad and that it seems evident that solid-state electrical properties are present. In addition to data sending involving the central nervous system, there may be another, concurrent system located within the cell, such that each cell contains its own data transmission system that does not depend on commands from a central point, but may react independently to stimuli of an electric or chemical nature.

Electricity and magnetism have been used to alleviate human ailments as far back as 600 B.C. when Aetius, a Greek physician, prescribed the shock of the torpedo (as electric fish) for the treatment of gout. (2:34) However, the controlled use of electric fields in electrotherapeutic application actually began with the invention of various electrical generators in the early part of the nineteenth century. Most of the early applications involved the direct application of electricity to the human body to obtain muscle and nerve stimulation. In 1930 a study of the effects of electricity on the human body led to the discovery that fibrillation is the lethal process in death by electric shock. This study paid great dividends which led to the development of closed-chest defibrillation (the reverse of fibrillation) and heart massage, procedures that have saved many lives. Related to this is shock treatment, which has proved beneficial to persons suffering from depression and schizophrenia. (2:35)

The use of electric fields has apparently proved to be more therapeutic than the mere presence of electric fields; this is the degree and nature of ionization of various constituents of air. Apparently when there is a large excess of positive ions to the number of negative ions, there are indications that deleterious effects occur in man such as reduced performance, tenseness and irritability. However, when an excess of negative ions exist, either naturally, or created by the application of artificial

electric fields, beneficial physiological and psychological effects have been noted. These effects are improved performance, increased work capacity, relief of pain and allergic disorders as well as a more cheerful disposition and enhanced burn recovery, healing and vitamin metabolism. (2:36)

In addition, alternating magnetic fields have been successfully applied to various parts of the body by means of solenoid induction coils. Physiological effects from this treatment are claimed to include the reduction of blood cholesterol, white cell count in blood, sedimentation rate, and blood pressure, as well as in the treatment of rheumatoid arthritis. (2:36 & 37)

Perhaps the most promising use of electromagnetic energy can be found in the Bordeaux Magnetic Machine, built at the University of Bordeaux by Antoine Priore. First developed to kill micro-organisms that produce rot in fresh fruit and vegetables, its primary use now appears to be in cancer treatment of animals with the final goal being the treatment of cancer in humans. (2:37)

The results of several experiments conducted with the wonderful Bordeaux Magnetic Machine are summarized below; (2:38)

1. A highly malignant strain of cancerous tissue, leukaemia, which can cause death in as little as two weeks, was grafted onto rats. Exposure to the radiation in the magnetic field resulted in the complete inhibition of growth of the cancerous grafts, or,

if the disease had started to develop before the treatment was begun, to its total regression.

2. Mice were inoculated with a microscopic blood parasite which causes sleeping sickness and death in a short time. All control animals died by the fifth day, while mice exposed daily to the radiation and magnetic field for 10-15 days usually survived (38 out of 46) with complete disappearance of the parasites and the development of a specific immunity to further infection.

Interestingly enough there appears to be a great deal of skepticism surrounding this mystery machine. As a result, a twenty man commission composed of well known men of science, law, and medicine, have begun an investigation. They have been able to verify experimental findings, but have not been able to provide an explanation of the workings of the Priore equipment. The French government is reported to be funding the construction of another more powerful machine in an attempt to determine whether this has been a great hoax or whether mankind has stumbled on a revolutionary scientific development. (2:38)

Athermal diathermy is the use of artificially induced local heat with no discernible rise in temperature for therapeutic purposes. Some speculate that these low athermal intensities may be more effective than thermal intensities in the treatment of tone tension of the spinal cord or brain and stimulation of

leucocyte production in connection with radiation injuries, as well as on malignant tumors.

There is also some controversy over athermal diathermy which is of great importance to the final judgment regarding the significance of electrical pollution. If athermal diathermy is proven to be an effective method of treatment, then other low-level methods of electrical treatment may also be useful. By the same token, it would follow that electromagnetic pollution would be expected to indeed have some level of physiological effect on man; a point which is presently not agreed upon in all circles. (2:40)

CHAPTER IV

OCCURRENCES OF KNOWN ELECTROMAGNETIC POLLUTION

"...one is forced to say that there have been relatively few recognized occurrences of known electrical pollution." (2:42)

As the effects of electromagnetic pollution upon individuals and the environment become more widely known, steps can be taken to alleviate those effects. Comparatively little research is being reported on the effects of this type of pollution, but there presently are large numbers of research programs underway throughout the United States. Some of the results of recent research in the area of electromagnetic pollution will be presented here. In doing so we must distinguish between effects which are "thermal" (heat with rise in temperature) as opposed to those that are "athermal" (heat with no rise in temperature). There are, of course, more known cases involving the effects of electromagnetic pollution since they are recognizable.

Thermal Electrical Pollution

The primary sources of thermal electrical pollution appear to be in the range of radio frequencies, especially at ultra-high frequencies and microwaves. It further appears that more physical

harm to humans was experiences in the past than is experienced today.

The Radiation Incidents Registry Report, 1970, published by the U.S. Bureau of Radiological Health reports two deaths claimed to be caused by excessive microwave radiation. The first case involved a 28 year old female assembler in a microwave equipment and manufacturing company in California. She was reported to have been exposed to radiation from a radar unit for a period of six months in 1952 and 1953; she hemorrhaged and died. The second case involved a 42 year old electronic technician at a microwave equipment manufacturing company in California. He reportedly worked ten feet from a radar transmitter. He experienced acute tissue destruction and died in 1954.

Other incidents of microwave effects have been reported on individuals. For example, a few years ago, a chef in a large Midwestern cafeteria specializing in quick service complained of excruciating pains in his abdomen. The preliminary diagnosis was appendicitis. Surgery revealed that the chef's internal organs were badly burned. The culprit was determined to be a microwave oven with a faulty door switch in the cafeteria where he worked. (5:56-60)

One of the greatest risks of electromagnetic pollution is borne by people with cardiac pacemakers. Pacemakers are extremely

sensitive to microwave radiation from many sources besides microwave ovens. In the presence of microwave radiation, the pacemakers react to the external source rather than the natural source and may speed up, slow down, or stop the heart. (5:56-60)

Studies have shown that exposure to microwave energy can bring about damage to the eyes; the foremost effect has been recognized as the formation of cataracts. This phenomenon verified with experiments involving animal, in which cataracts are formed both on the anterior and on the posterior locations of the lenses of the eyes. Anterior cataracts are associated with gross eye damage, whereas posterior cataracts are usually delayed and occur at lower levels of microwave exposure. (8:371)

However, all are not in agreement on the effects of microwave radiation. B. Appleton reported in an article in the 1974 Journal of the American Medical Association entitled 'Microwave Cataracts' that, "It is reasonable to conclude that no lens damage was caused by occupational exposure to microwave energy." He doubts that the cumulative effects occur and thinks that lens damage could not occur in a human from acute exposure without being accompanied by severe facial burns. He believes that microwaves are safe to humans if existing standards of safety are observed.

6 Scientists in the Soviet Union have reported thyroid changes in workers after exposure to microwaves. They noted enlargement of the gland in some cases, along with an increased absorption of

radioactive iodine by the thyroid. They suggest that these effects may be due to a direct neurological effect resulting from the stimulation of the pituitary gland located at the base of the brain which caused an increase in the hormone thyrotropin. Work on laboratory rats by W.C. Milroy and S.M. Michaelson as reported in Aerospace Medicine in 1972, however, does not appear to support the concept of a direct athermal effect of microwave radiation on the neuroendocrine system and suggest that further studies be undertaken in higher animals. (2:49)

The "Radiation Incidents Registry Report, 1970" of the U.S. Bureau of Radiological Health also reported a number of other effects of exposure to high frequency and microwave radiation, such as skin lesions and burns, genital discomforts, blood disorders (including leukaemia), stress syndrome, temporary adrenal insufficiency as well as fainting and fatigue.

Athermal Electrical Pollution

There are only a few known cases of electrical pollution which can be accurately classified as athermal:

1. Phosphenes is the sensation of light flashes in the eye; the flashes are colorless or faintly tinted blue or yellow and may be produced by an alternating magnetic field. This phenomenon was probably first noted by Michael D'Arsonval in 1893. The history of the work on phosphenes was surveyed by Harold S. Alexander in 1962

and suggests that the cause of phosphenes may be in the retina of the eye, presumably being the result of eddy currents. Pressure on the eyeball can temporarily stop the visual sensation, and with constant stimulus a decrease in the brightness of the phosphenes occurs with time. Occurrence of phosphenes have been reported in workmen in a nitrate factory at Notodden, Norway, probably from large choke coils used to limit the current supplied to electric furnaces. (2:42&43)

2. Cardiovascular System - scientists in the USSR have gathered information from clinical investigations of persons who have been chronically exposed to electromagnetic radiation, especially in the 300-10,000 MHZ range and its effects on the cardiovascular system. These effects fall into three categories; reduced blood pressure, slow heart beat, and electrocardiograph changes. The effects were most pronounced at the high end of this frequency range for which electromagnetic energy is absorbed in the surface tissue of the human body. It is theorized that these changes in the cardiovascular system are due to the direct action of electromagnetic energy on the surface receptors of the nervous regulatory system. (2:44)

3. The effects of geophysical parameters are perhaps one of the most interesting athermal phenomenon reviewed by this author. The correlation of biological parameters (blood pressure, leucocyte count, etc.), illnesses and deaths with geophysical disturbances has been the subject of interested study since about 1935. The

experimental investigations suggest that a central role is the change in environmental magnetic and electric fields and atmospherics. (2:45)

a. Incidence of cerebrospinal meningitis in New York, and the incidence of relapsing fever in the USSR were correlated with solar activity.

b. The rate of psychiatric hospital admissions were correlated positively with geomagnetic storms.

c. Total number of admissions to hospitals and the number of deaths in hospitals were also correlated with geomagnetic storms.

d.. Mortality from nervous and cardiovascular diseases were correlated with magnetic storms in Copenhagen and Frankfurt-on-Main.

e. However, in 1966, A.D. Pokorny and R.B. Mefferd examined the relationship between 2017 homicides, 2497 suicides and 4953 psychiatric hospital admissions, and seven related measures of geomagnetism. They concluded that geomagnetic fluctuations do not influence psychiatric hospital admissions, suicides or homicides. The study involved 1096 days in 1959-1961, which happened to be a period of decreasing solar activity. (2:45)

Extra High Voltage Transmission

The electric fields produced by power lines are known to have an effect on animals. Male mice when exposed to strong electric fields for 6.5 hours per day for 6 months produced smaller offspring than mice of a control group. It is significant that in that experiment, the female mice and baby mice were never exposed to the electric fields. Another study conducted by a power company involved ten linesmen who did repair work on 345,000 volt lines. They were checked over a nine-year period and three men were found to have reduced sperm counts. In the Soviet Union, men working at substations for a 500,000 volt power line began to complain of headaches and general depression after a short time at the substations. The symptoms were attributed to the power line. (10:34-48)

CHAPTER IV

CONCLUSIONS

J.H. Battoclette, author of Electromagnetism, Man and The Environment, summed up the situation quite adequately when he said, "...the general public is oblivious to the possibility, or perhaps the probability, that they are being affected adversely by the electricity and magnetism around them." (2:42)

The primary conclusion derived from readings in the field of energy pollution is that electromagnetic pollution pervades our lives to a greater extent than suspected by many people; evidence of electromagnetic pollution is being found in many areas of our lives. Pollution caused by power lines and transmitting stations are now beginning to be studied. There are tremendous amounts of energy being broadcast by these devices and only now are some of the effects on people being discovered. However, there is no conclusive evidence supporting the hypothesis that there might be significant long term biological and psychological ill effects from extra high voltage installations using the present commercial frequencies.

All this does not mean that no further investigations are required, quite the opposite - the need for an interdisciplinary approach is becoming more and more clear - the need of bridging the gap between the sciences, medical, psychological, environmental, and physical, in order to better understand and to be in a position to assess the limits of how much voltage and what fields can be increased without causing biological effects. There does not appear to be any technical indications for crash programs or for public concern regarding the present situation. (1:13)

Unfortunately, there seems to be a current trend to not report all electromagnetic radiation accidents. John M.R. Bruner stated in an article entitled, 'The Horror of Common Practice' for a 1970 National Academy of Sciences workshop on Electric Hazards in Hospitals,

There is a lack of useful information in an era infatuated with communication. Accident reports have virtually disappeared from journals; chilly responses meet inquiries directed to agencies whose business it should be to know about electric injury. Without reliable data on the incidence and cause of illness, intelligent planning of preventive measures is not possible..

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